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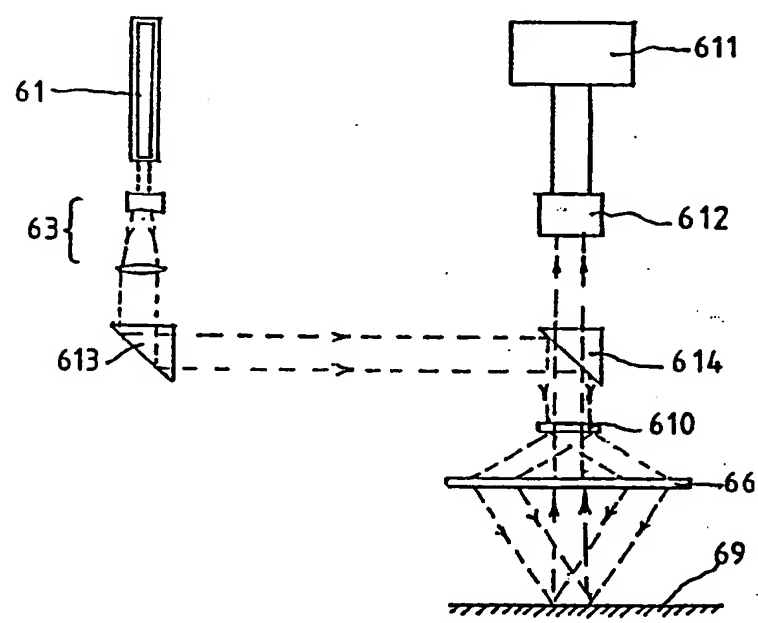
(54) Title: DISTANCE GAUGE



(57) Abstract

A non-contact, optical distance measuring gauge comprises a single laser (61) light source producing a highly collimated light beam, a beam expander (63) to expand that beam and direct it by way of a 100 % mirror (613) and a 50 % mirror (614) to a divergent diffraction grating (610) to convert the beam into two spaced apart diverging beams. The spaced beams pass through a convergent grating (66) and are directed as converging beams towards a target surface. The convergent grating is patterned or masked to cause each converging beam to illuminate a column or columns of corresponding rectangular areas on the target surface. The illuminated target is viewed by a solid state, array type, video camera (611), a frame of the camera output is digitised and the digitised data processed to determine a mean value of the displacement of the edges of corresponding areas illuminated by the respective beams, to provide a high precision indication of the distance of the target from the gauge.

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DISTANCE GAUGE

TECHNICAL FIELD

The present invention relates to apparatus for the measurement of the distance from the apparatus to an external object, of the kind which utilise changes in the observed position or size of a light pattern cast upon the target object to determine the distance to the target.

The invention was devised primarily to determine the thickness of a paint or other coating applied to a moving strip (by measuring the distances of the opposite sides of the strip from each of two sets of apparatus according to the invention between which the strip moves, and deducting those distances from the spacing between the two sets of apparatus to determine the thickness of the strip, both before and after it is coated), but is equally applicable to other situations wherein a precise indication of the distance of an external target object is required and wherein physical contact with the object is precluded or undesirable.

BACKGROUND ART

One known technique, as disclosed in Publication No. WO 88/07657 of the International application PCT/AU88/00084 (by The Commonwealth Scientific & Industrial Research Organisation) utilises a narrow rectangular converging light beam, that is to say one focussed on a focal line, which is directed upon a target surface so that the focal line obliquely intersects the surface. The illuminated area is observed by a video camera and the target distance determined with reference to the position of the brightest point in the camera's field of view, which point represents the point on the focal line at which it intersects the surface. This technique actually determines the distance of a point on the target surface and to attain high

precision the optical viewing element has to be so close to the target surface as to render the device unsuitable for use in relation to moving strips or sheets in an industrial environment.

According to another prior known technique the optical axis of a viewing device and a light beam are arranged to converge and intersect at or near the target surface, a collimated beam is used and the position of a, possibly relatively large, feature of the illuminated area, (for example, an edge of the illuminated area), in relation to the field of view of the viewing device indicates the distance between the viewing device and the target. In that the feature may be large, and thus indicative of an "average" distance of the surface rather than the distance of a point on the surface, this technique is able to be applied to moving, substantially planar, surfaces. This known technique is illustrated diagrammatically by figure 1 herewith, wherein a projector 10 directs a narrow collimated beam at a target surface 11 within the field of view of a camera 12. The beam and the optical axis of the camera lie converge and intersect near the target surface 11. The distance S of the illuminated area from the edge of the field of view of the camera 12 is linearly related to the distance X between the target surface 11 and the camera 12.

According to still another known relevant technique two light beams are directed towards the target so that they converge and intersect near the target surface and the distance between the two illuminated areas so produced is taken as an indication of the distance of the target. This known technique is illustrated diagrammatically by figure 2 herewith, wherein two projectors 20 project narrow collimated beams towards a target surface 21 within the field of view of a camera 22. The beams converge and intersect, or would intersect if extended, near the target surface 21. The distance S between the two illuminated

areas is linearly related to the distance X between the target surface 21 and the light sources 20.

This last-mentioned technique is closely related to the invention and is exemplified by the disclosures in the specifications of Australian patent No.258220 (to United States Steel Corporation) and U.S. patent No.4498776 (to General Motors Corporation).

The two last-mentioned techniques are characterised by the spacing between, and alignment of, two separate components of the gauge, that is to say, a base line extending from one component to the other, and the angle of convergence of axes related to those components. Thus, both suffer from the disadvantage that the relative positions and orientations of several separate components (the beam source, the associated optics, and the light detector) are critical to the accuracy of measurement. Any change in the base line or the angle of convergence due to vibration, shock or thermal expansion will lead to errors in measurement.

For example, a known device of the figure 1 type with a stand off of 95 mm and a nominal angle of convergence of 45°, would give a 0.5 μm error if the actual angle of convergence were in error by about one second of arc or if the error in base line length were about 0.5 μm. Such small errors in angle and base line could be caused quite easily in an industrial environment, and the resulting error in distance measurement would be unacceptable in some applications.

DISCLOSURE OF THE INVENTION

An object of the present invention is to provide a distance gauge capable of use for determining the distance to a moving workpiece, in, for example, a continuous galvanizing plant or similar harsh industrial environment,

to a precision enabling a meaningful determination of, for example, the thickness of the zinc coating being applied to the workpiece, to be made.

The invention achieves that object by providing a gauge of the kind utilising two converging light beams, but wherein possible variation in the relative disposition of the sources of each beam is virtually eliminated and wherein the stability and resistance to vibration, shock and thermal effects is otherwise greatly enhanced by comparison with prior art devices, so enabling higher precision to be obtained.

The invention flows in part from the appreciation that some relative movement of the viewing device and the illuminated areas may be tolerated provided the converging light beams do not move relative to each other and according to the invention this is assured by deriving both beams from a common source by means of a single sequence of individually integral, optical elements. Thus, in accordance with the invention, there are no separate components or assemblies specific to the individual converging beams, only zones of one piece components. This means that the accuracy and constancy of the initial separation of the converging beams (the base line) and of their angle of convergence, depends more on the precision and dimensional stability of the individual optical elements, rather than on the constancy of the relative position and orientation of separate components or assemblies, as in the prior art.

Devices according to preferred embodiments of the invention attain high precision of measurement not only because they generate a pair of converging beams with an extremely stable base line and angle of convergence but also because they provide means for accurately determining the relative separation of the illuminated areas on the target surface.

Preferred embodiments of the invention make use of visible light because of the ready availability of precision apparatus adapted thereto, but it will become apparent to those skilled in the art that infra-red or ultra-violet light could be used in specialised versions of the invention, providing appropriate sources and detectors of such energy were used in place of more conventional optical apparatus. Thus the term "light" as used herein is intended to embrace at least infra-red, visible, and ultra-violet light, "illuminated" is to be construed accordingly, and terms such as "lamp" or "camera", commonly used to indicate optical devices functioning with or by visible light, are to be read, where the context allows, as including analogous devices adapted for use with infra-red or ultra-violet light.

Therefore, the invention consists in a distance measuring gauge of the kind comprising beam generation means to project two substantially converging light beams towards a target surface and viewing means to determine the displacement of the illuminated areas produced on the target surface by the respective converging beams, characterised in that said beam generation means comprise a light source and a single sequence of individually integral, optical elements deriving both converging beams from that source.

In preferred embodiments of the invention, said light source generates a single collimated beam and said sequence of optical elements comprises a beam splitter to convert the single beam into two spaced apart beams and redirecting means causing said spaced apart beams to converge towards the target surface.

Also, in preferred embodiments, the invention is further characterised in that the converging light beams are slightly spaced apart laterally instead of being "co-

planar" as in the prior art. This causes the illuminated areas to be laterally separated and prevents them overlapping on the target surface. This, in turn, facilitates observation of their displacement, as measured in a direction perpendicular to the direction of their lateral separation. However for descriptive convenience views of such preferred embodiments taken in the direction of the lateral separation make no attempt to distinguish between the near beam and the far beam, and beams which appear to "intersect" when so viewed and the illuminated areas produced by them on the target surface are discussed, where convenient, as if they were truly coincident.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a diagrammatic illustration of a prior art distance gauge.

Figure 2 is a view similar to figure 1 of another prior art gauge.

Figure 3 is a diagrammatic illustration of the beam generation means of a distance gauge according to one embodiment of the invention.

Figure 4 is a view similar to figure 3 in respect of another embodiment of the invention.

Figure 5 is a diagrammatic illustration of a distance gauge according to the invention including the beam generation means of figure 3.

Figure 6 is a view similar to figure 5 of another embodiment of the invention including a modified version of beam generation means according to figure 4.

Figure 7 is an enlarged diagrammatic representation of

a mask, being a component of the beam generation means of any one of figures 3 to 6.

Figures 8 to 11 are diagrammatic illustrations of the illuminated areas of a target surface produced by beam generation means including a mask according to figure 7, under differing circumstances.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following description components appearing in the several figures 3 to 7 having equivalent functions bear corresponding reference numerals except for an initial numeral indicating the relevant figure.

In the beam generation means illustrated by figure 3 there is a single light source, namely a laser 31, which produces a single highly collimated beam 32. The degree of collimation depends upon the flatness of the mirrors at each end of the laser and on the diameter of the beam as it leaves the laser. Mirrors of extremely high quality are commercially available, so, in practice, the major factor limiting the degree of collimation is the diffraction effect related to the aperture of the laser.

For an aperture of 1 mm and a wavelength of 632.8 nm (HeNe laser), the angle of divergence is 2.7 minutes. Even better collimation is possible if a laser with a wider aperture is used.

The deleterious effects of diffraction from a small aperture source are overcome substantially in the figure 3 generation means by means of a beam expander 33 placed immediately after the laser 31. By increasing the effective aperture of the beam from perhaps 1 mm to 10 mm or so a very much higher degree of collimation may be achieved (16 seconds of arc). Of course, the optical quality of the components in the beam expander 33 limits

the degree of collimation achievable, but the present requirements are relatively modest, and can be fulfilled by low cost, commercially available equipment.

The single beam 32 is split into two separate, spaced apart beams 34 by an interposed mask 35 which masks out unwanted portions of the expanded single beam.. In practice, the mask 35 may be an integral part of the next met optical element in the light path, namely a convergent diffraction grating 36.

Two disadvantages of masking are that a large proportion of the incident light is wasted, and that the diameter of the incident single beam has to be large if a long base line is required. Longer base lines lead to a higher proportion of wasted light and to the need for a more expensive beam expander. In spite of these disadvantages, a short base line, masked system, as illustrated in figure 3, is simple and cheap, and may give distance measurements of accuracy adequate for many applications.

The convergent diffraction grating 36 bends the spaced apart beams incident on it and directs them as converging beams 37 and 38 respectively which intersect on or near the target surface 39.

Figure 4 illustrates a somewhat more sophisticated beam splitting arrangement. It comprises a laser 41 producing a single collimated beam 42 and a beam expander 43. The degree of expansion of the beam 42 produced by the expander 43 may be considerably less than that produced by the expander 33. In this instance the expanded beam falls upon a divergent diffraction grating 410 which divides it into two diverging, spaced apart beams 44. The beams 44 fall upon a convergent diffraction grating 46, which may be preceded by a mask (not shown) ultimately defining the beams reaching it, and

are then directed as converging beams 47 and 48 towards the target surface 49.

The figure 4 arrangement has the advantage over the figure 3 arrangement of providing a very long base line, together with a small proportion of wasted light, without the need for an expensive beam expander. The only disadvantage is that an additional high quality optical element is needed.

In both the figures 3 and 4 arrangements, the mask preceding the convergent grating may be dispensed with in favour of a custom made grating, with the grating lines restricted to certain areas. Only those parts of the beam incident on these areas are diffracted, so that the shape of the convergent grating itself then becomes a highly accurate and stable equivalent to a mask. Alternatively, a separate mask may be used to shape the converging beams. This mask may be either free standing or preferably attached to the surface of the convergent grating.

For short base line systems (figure 3) the convergent grating may be quite compact and extremely rigid. In the case of long base line systems (figure 4) the grating would have to be much larger, and some care may have to be taken to minimize bending of the grating by clamping pressures. Also, the grating would be more expensive.

In both arrangements the stability of the base line depends on the dimensional constancy of the convergent grating, while the accuracy of the angle of convergence of the two beams depends on the degree of collimation of the initial single beam from the laser. Both of those factors are inherently constant by comparison with the stability of the assemblage of components of the prior art.

Gauges according to the invention include viewing means for measuring the relative displacement between the

two areas illuminated by the converging beams incident on the target. Fundamentally those means comprise an optical sensor, for example, a video camera, with a field of view which overlaps the illuminated areas, able to generate a signal related to the position of a feature in each region, so that the difference between the two signals indicates the distance between the features.

Figures 5 and 6 show two possible configurations, in gauges according to the invention, of the sequence of optical elements for generating the two convergent light beams and the viewing means. The target areas illuminated by the beams are contained substantially within the field of view of the viewing means.

The gauge illustrated by figure 5 comprises beam generating means according to figure 3 comprising a laser 51, beam expander 53, a separate mask 55A, a second mask 55B applied to a convergent grating 56, and a video camera 511 with a lens 512 through which it obliquely views the illuminated areas on the target surface 59.

Mask 55A is a relatively coarse mask blanking out most of the light but allowing light to fall on the operative areas of mask 55B. The latter is a precise mask producing the final beams, being integral with the grating 56 it is dimensionally very stable.

The gauge illustrated by figure 6 comprises a laser 61, beam expander 63, divergent grating 610, convergent grating 66 and a video camera 611 with lens 612 through which it views the target surface 69. In this instance the camera 612 is aligned directly with the illuminated areas by virtue of two mirrors 613 and 614. The mirror surfaces may conveniently be inclined faces of high precision prisms. Mirror 613 is a 100% mirror and directs all of the expanded laser beam to mirror 614. Mirror 614 is a 50% mirror and directs half of the incident

beam to the grating 610. It also permits reflected light from the illuminated target to travel through it to the camera lens 612, as will be readily appreciated by those skilled in the art.

In the simplest embodiments of the invention the cameras 511 or 611 may be commercially available line scan cameras adapted to directly measure the relative positions of the two illuminated areas on the target. For preference, however, the viewing means comprise a solid state, area array type camera together with vision processing equipment able to determine the relative displacement of the two areas with extremely high accuracy.

Suitable apparatus and its method of use are described in the specification of our Australian application No. 15128/88 entitled "Non-Contact Determination of the Position of a Rectilinear Feature of an Article", all of which is included herein by reference.

Although the individual photo-sensors of solid state area array cameras exhibit small variations in response to incident illumination (due to small variations in sensor characteristics, variations in the surroundings of the photo-sensors, and random noise variations), the regular array allows many independent measurements to be made on different parts of a large object. Averaging the many independent measurements gives a statistical reduction of errors, so that the array can give extremely sensitive measurements of position.

In the operation of gauges having the preferred array camera and image processing means, an image of the target area is focussed onto the array of photosites of the camera, where signals are generated proportional to the amount of light which falls on each site. At regular periods these signals are extracted from the array, and the photosites are cleared. The extracted signals are clocked

out of system in a regular, well defined way, so that the previous spatial order of the image is converted into an ordered time varying signal. It is preferred to set the clocking frequency in a certain range, to insert various other signals at defined intervals, and to amplify the signal to a certain level, so that the resultant signal conforms to one of the standard video formats (such as CCIR or RS-170). Other approaches are possible, and there is commercially available equipment which, in order to obtain technical advantages, employs some of those alternatives.

The video signal from the camera is transmitted along a cable to a digitizer, which samples the incoming signal at regular intervals, converts the sampled value to a digital number representing the degree of saturation, and sends the result to a special area of computer memory called a framestore. Most video digitizers generate numbers with values between 0 and 255, with 0 representing black, 255 representing white (saturation), and intermediate numbers representing various shades of grey. Each memory location in the framestore contains information about the brightness of a particular part of the image captured by the camera, so that the data in the framestore as a whole records the image and may be regarded as a representation of the image. As detailed in our mentioned Australian application algorithms have been formulated to enable a computer to process the framestore data to determine the positions of features of the image relative to the image as a whole, which is equivalent to determining the positions of features of the viewed scene relative to the camera's field of view.

Perhaps the simplest feature of which the position can be determined with high accuracy is a straight line edge. The processing algorithm preferably uses the statistics of large numbers of measurements, individually referable to closely spaced positions along the edge, to produce a mean value for the position of the edge to reduce both random

errors and aliasing errors. Accuracy is expected to increase with the square root of the number of pixels in the length of an edge. Thus it would seem that an edge which is 10000 pixels long could be measured to an accuracy of ±0.2% of a pixel spacing.

Likewise accuracy may be increased by using the mean displacement of a large number of edges in one illuminated area relative to nominally corresponding edges in the other. For preference, then, the areas on the target surface illuminated by each of the converging beams display a pattern having a large number of straight edges extending in a direction perpendicular to the direction of the displacement to be determined, with half of the edge lengths coming from one of the converging beams and half from the other.

Figure 7 shows a mask 75 which may be used to provide such a pattern of illuminated areas. One of the converging beams would shine through rectangles 715 and the other through rectangles 716. Thus the slight lateral displacement of the so-called intersecting beams referred to earlier is obtained. This mask 75 could be a more detailed version of the mask 35, or could be in addition to the mask of Figure 3. Then again, figure 7 could represent the convergent grating 36 itself (with grating lines being drawn only within the masked rectangles). Similar masks or ruled grating areas may be used with or on the convergent gratings 56 and 66 of the illustrated gauges.

If the mask of figure 7, or its grating equivalent, is used in either illustrated embodiment a series of bright rectangles as shown in figures 8 to 11 may appear on the surface of the target.

In Figure 8 the alignment of the optical elements is ideal, and the target coincides exactly with the plane of intersection of the converging beams. Figure 9 shows the

relative shift in the illuminated rectangles when the target is brought closer to the gauge.

Finally, Figure 10 and Figure 11 show the pattern when the target is tilted in different (orthogonal) directions with respect to the axis of the optical components.

Bilateral symmetry is a feature of the mask (or grating pattern) which allows tilting angle errors like those shown in Figures 10 and 11 to be compensated for automatically, without any need for special calculation (provided the tilting errors are small).

The number of illuminated rectangles that can be used governs the total length of edge that is available for measurement. A small number of rectangles gives a small length of edge, and hence low accuracy. If the number of rectangles is too large then the camera may not have sufficient resolution to discriminate between them. The maximum number that could be tolerated with conventional low cost CCD array cameras, with about 500 by 500 pixels, is about 25. In this case each rectangle (and the spaces between them) is about 10 pixels wide. If the tilt in each rectangle is say 5 pixels (a reasonable value, giving good reduction of aliasing errors) then simple techniques for identifying and locating the edges of the rectangles may not work for larger numbers of rectangles.

Another factor which could limit the number of rectangles is the depth of field necessary. If the target is located exactly at the plane of intersection of the two converging beams, then the areas illuminated by the two beams will be aligned exactly, as shown in Figure 8. As the target is moved towards or away from the measurement system the illuminated areas of each beam move apart (Figure 9). Continuing the movement will cause parts of the illuminated areas to move out of the field of view of the camera. Eventually, both areas will move completely

out of the field of view. If the algorithm used depends upon the whole of both sets of illuminated areas being present within the field of view, then an unused margin of the field of view must be provided to allow significant relative motion between the images. The larger the width of the margin, the more scope there is for relative motion, and the greater is the depth of field of the apparatus. Large margins, however, take up space that could be occupied by rectangles, and hence reduce the length of edge utilized, and lower the accuracy of measurement.

An alternative approach is to have the series of rectangles extend beyond the field of view of the camera in both directions. This increases the depth of field, and allows the whole field of view to be filled with rectangles all the time, thus maintaining accuracy. The obvious disadvantage is that ambiguity is introduced, since there is no way of identifying which inner rectangle corresponds to which pair of outer rectangles. Positive identification can be achieved by having rectangles with slightly different widths, with the widths being easily measurable. Matching the patterns of widths between the central and outer rectangles allows positive correlation. The only remaining disadvantage is that calibration may be difficult, as step changes may occur as rectangle sets move out of or into the field of view of the camera.

Assuming that each of the outer rectangles 714 is 100 pixels wide, and the inner rectangles 716 are each 200 pixels wide, each set of rectangles contains about 10000 pixels lengths of edges if there are 25 rectangles in each set. This gives a potential accuracy of 0.2% of a pixel spacing in locating one set, and a relative error between the two sets of about 0.3% of a pixel spacing.

CLAIMS

1. A distance measuring gauge of the kind comprising beam generation means to project two substantially converging light beams towards a target surface and viewing means to determine the displacement of the illuminated areas produced on the target surface by the respective converging beams, characterised in that said beam generation means comprise a source of light and a single sequence of individually integral, optical elements deriving both converging beams from that source.

2. A gauge according to claim 1 further characterised in that said sequence of optical elements comprises conversion means to convert a single beam from said source into two beams, and redirecting means causing said two beams to converge towards the target surface.

3. A gauge according to claim 1 further characterised in that said source is a laser.

4. A gauge according to claim 2 wherein said sequence of optical elements further comprises a beam expander between said source and said conversion means.

5. A gauge according to claim 2 wherein said conversion means comprises a divergent diffraction grating.

6. A gauge according to claim 2 wherein said redirecting means comprises a convergent diffraction grating.

7. A gauge according to any one of the preceding claims further characterised in that said viewing means comprise a video camera and image processing means whereby said displacement of the illuminated areas is determined.

8. A gauge according to claim 7 wherein said camera is of the kind having an image receptive means comprising an area array of light sensitive receptors disposed in rows.

9. A gauge according to claim 8 further characterised in that the target surface areas illuminated by the respective converging beams are spaced apart in a direction perpendicular to the direction of the displacement of the illuminated areas which is to be determined.

10. A gauge according to claim 8 further characterised in that one converging beam illuminates at least one discrete area of said target surface, and in that for the, or each, area illuminated by said one of the converging beams there is a corresponding discrete area or plurality of discrete areas illuminated by the other converging beam.

11. A gauge according to claim 10 further characterised in that each said discrete area is substantially quadrilateral with at least one pair of substantially straight parallel edges.

12. A gauge according to claim 11 wherein said edges are substantially perpendicular to the direction of the displacement of the illuminated areas to be determined.

13. A gauge according to claim 11 wherein said edges are substantially parallel to or slightly skewed with respect to the row direction of the receptors of the area array of said camera.

14. A gauge according to claim 10 wherein both said converging beams illuminate a plurality of said discrete areas further characterised in that said image processing means determine said displacement as the mean displacement of corresponding edges of corresponding areas illuminated respectively by the converging beams.

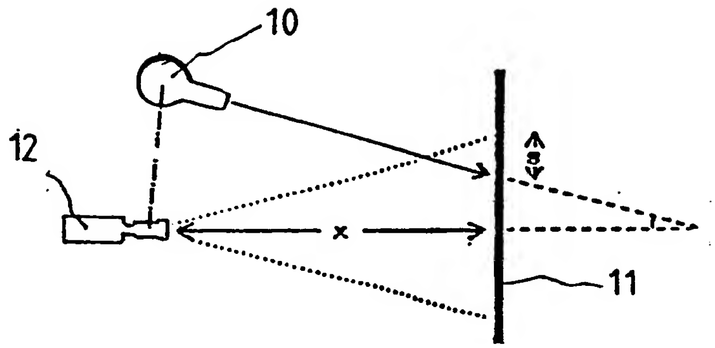
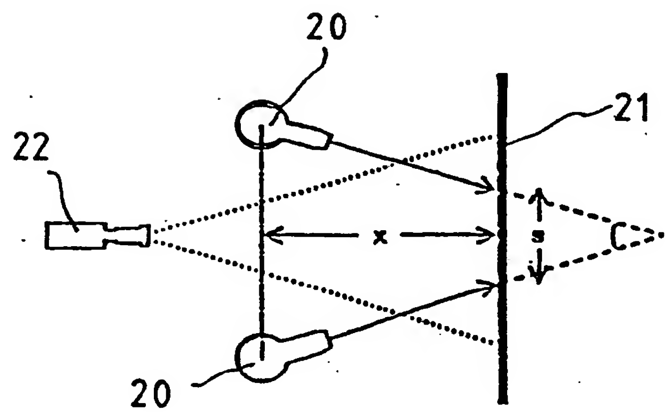


FIG 1

FIG 2



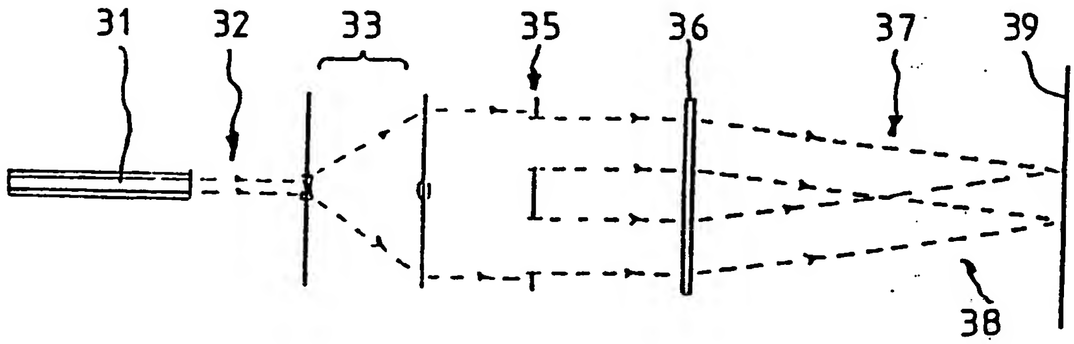


FIG 3

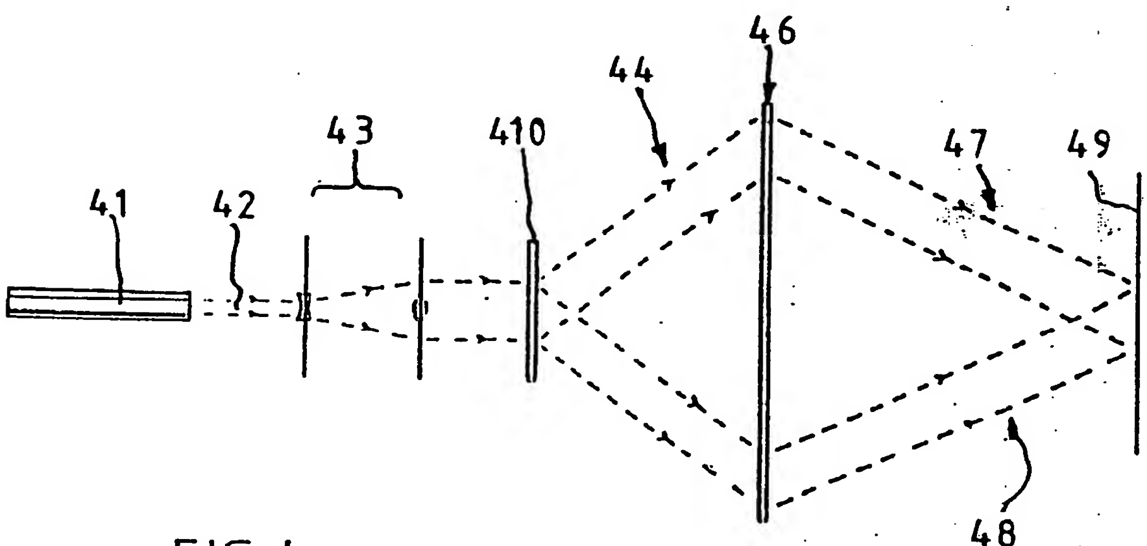


FIG 4

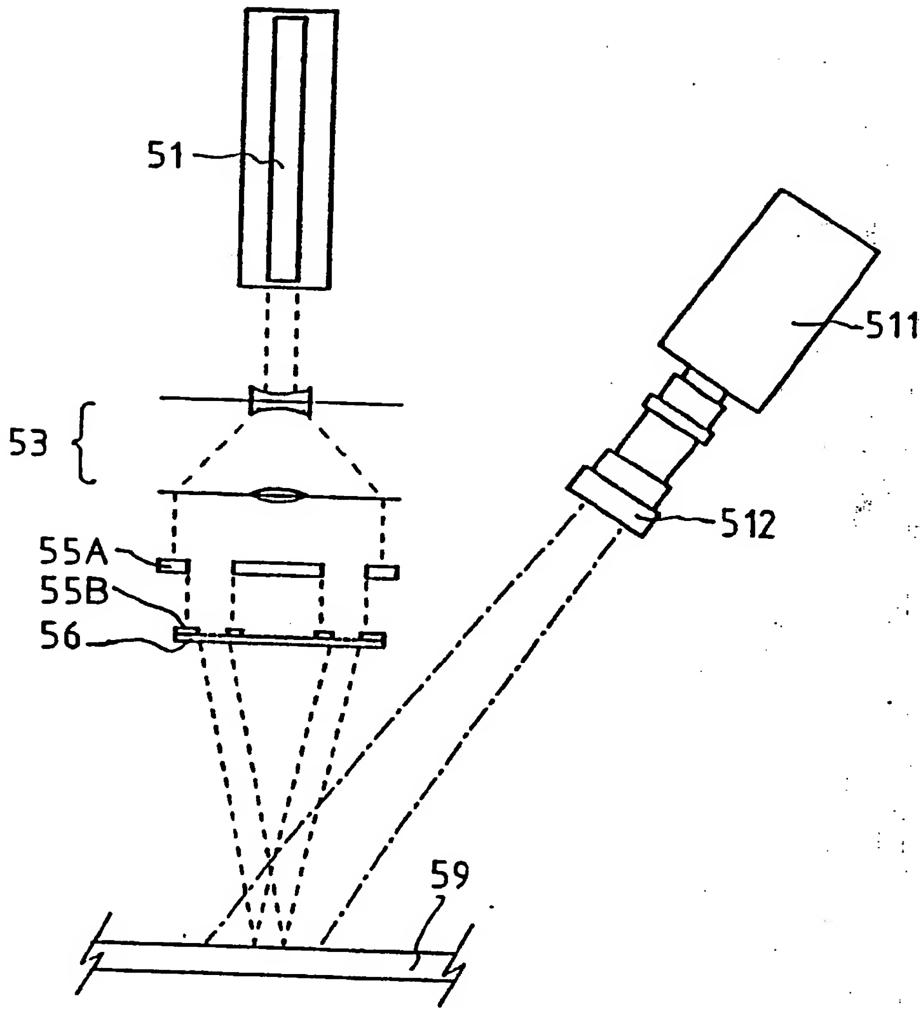


FIG 5

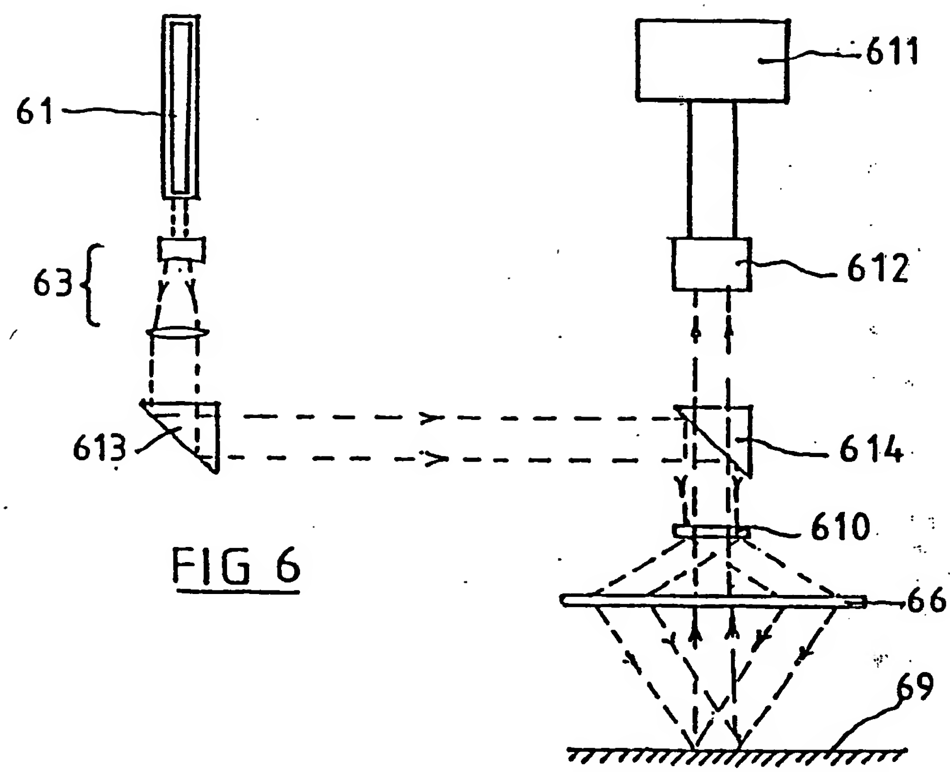


FIG 6

FIG 6

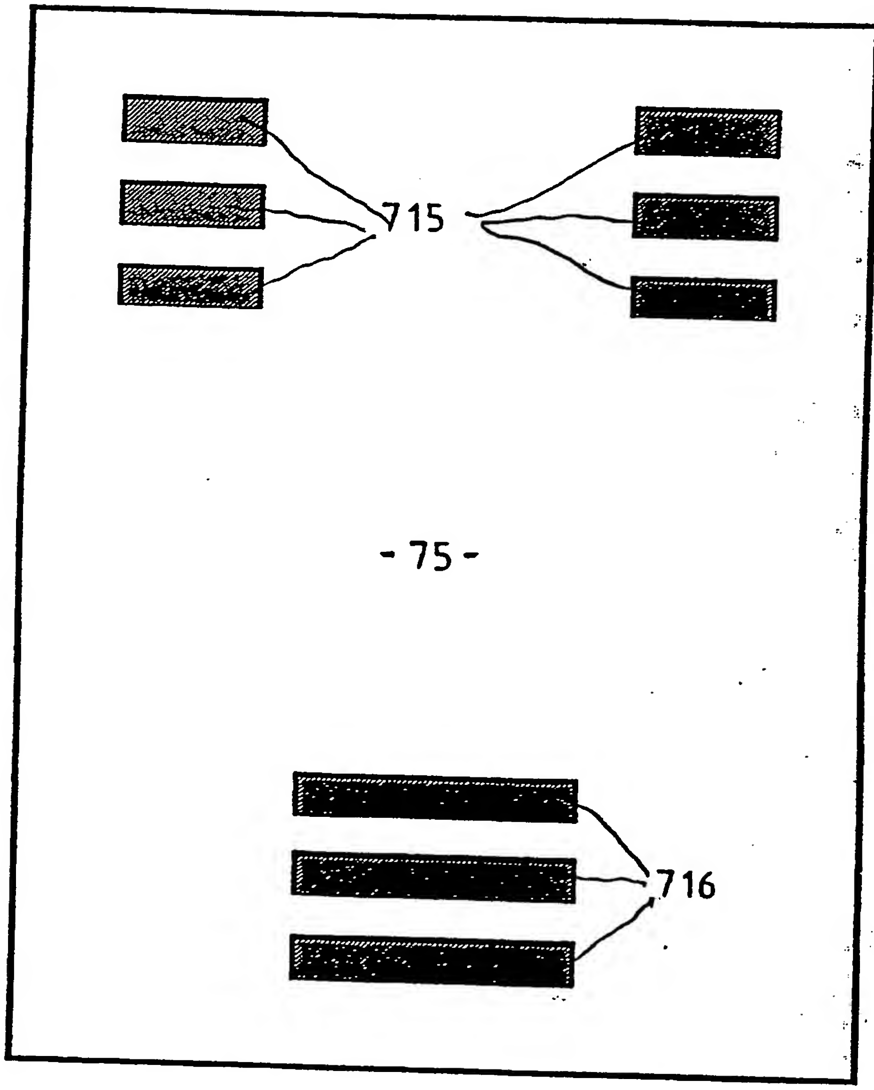


FIG 7

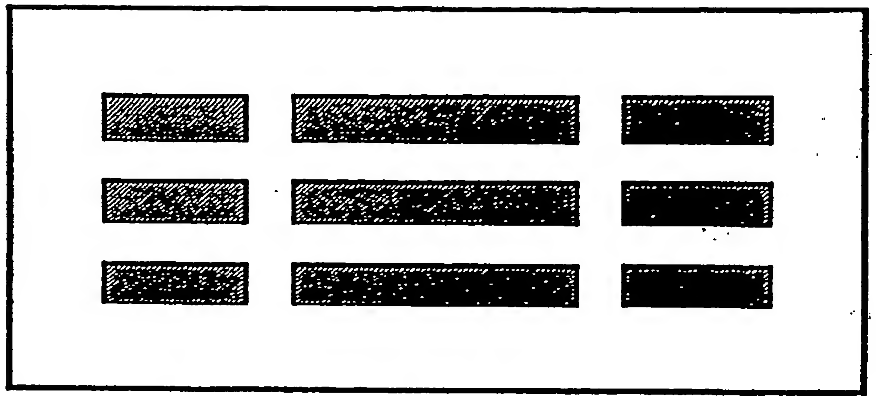


FIG 8

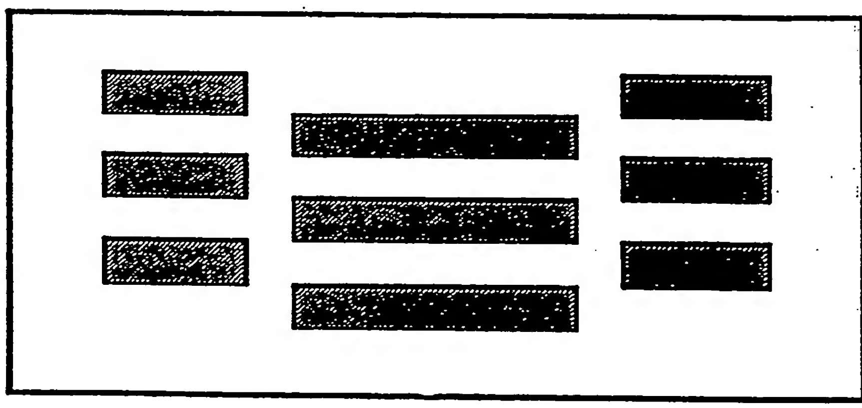


FIG 9

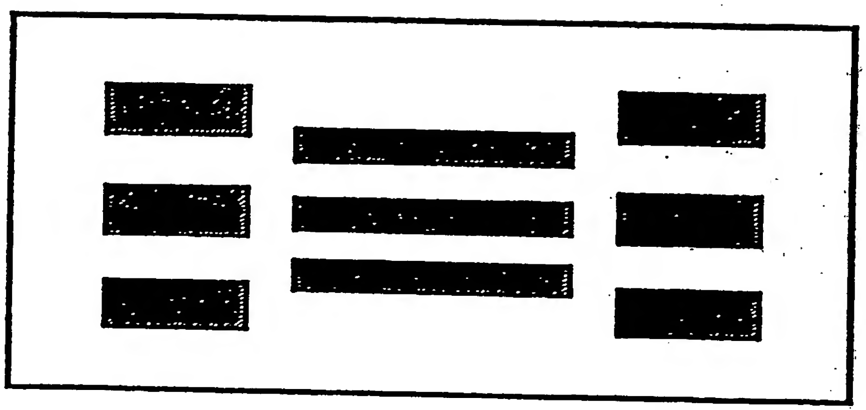


FIG 10

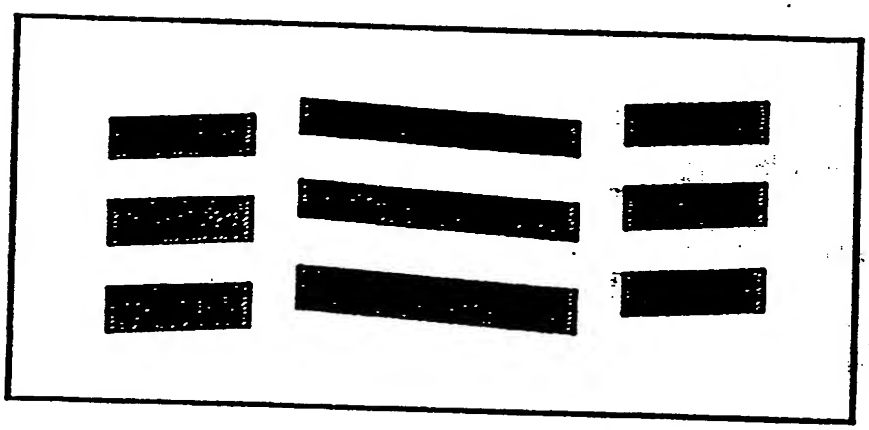


FIG 11

INTERNATIONAL SEARCH REPORT

International Application No. PCT/AU 90/00061

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 6

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.[5] G01B 11/06, 11/14, 11/00; G01C 3/00, 3/08

II. FIELDS SEARCHED

Minimum Documentation Searched 7

Classification System	Classification Symbols
IPC	G01B 11/06, 11/14; G01C 3/06, 3/08

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 8

AU : IPC as above; Australian Classification 00.4

III. DOCUMENTS CONSIDERED TO BE RELEVANT 9

Category*	Citation of Document, 11 with indication, where appropriate, of the relevant passages 12	Relevant to Claim No 13
A	AU,B, 12295/61 (258220) (UNITED STATES STEEL CORPORATION) 13 June 1963 (13.06.63)	
A	US,A, 4498776 (SMITH) 12 February 1985 (12.02.85)	
A	DE,A, 3629435 (KABUSHIKI KAISHA TOSHIBA) 12 March 1987 (12.03.87)	

* Special categories of cited documents: 10

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
4 April 1990 (04.04.90)	19 April 1990
International Searching Authority	**Signature of Authorized Officer**
Australian Patent Office	W.J. MAJOR W. J. Major

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL APPLICATION NO. PCT/AU 90/00061

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned internation search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Members
DE 3629435	JP 62049208

END OF ANNEX

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